

ADVANCED NON DESTRUCTIVE EVALUATION (NDE)

IN SUPPORT OF
COMBAT READINESS



**RAD
TECH**

by

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NDIA 20th Annual T&E
Conference

#1 PRIORITY OF COMMANDERS

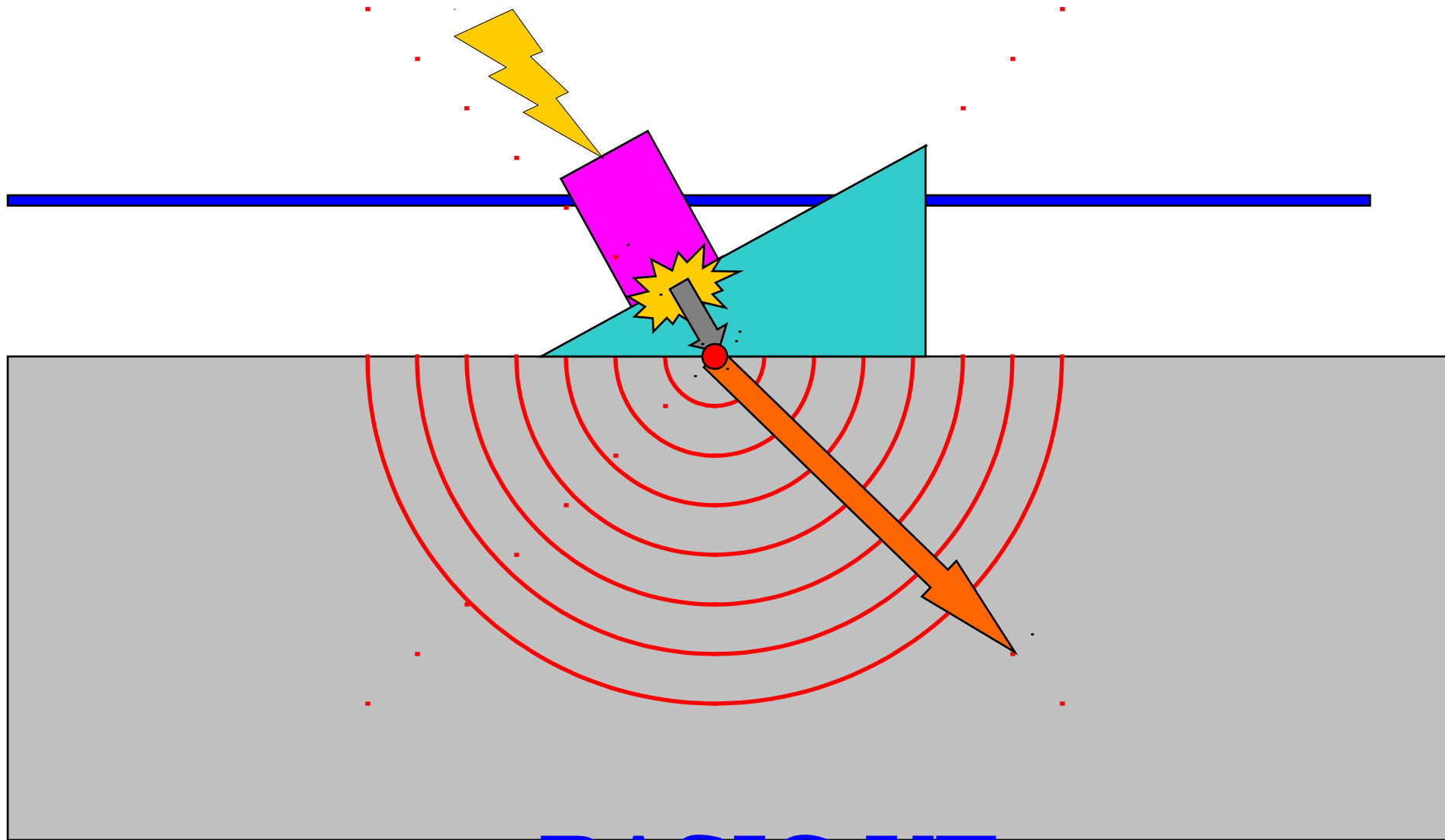
COMBAT READINESS



Performance = Quality Control from
Manufacturing Floor to Theater of

Technologies as a SOLUTION

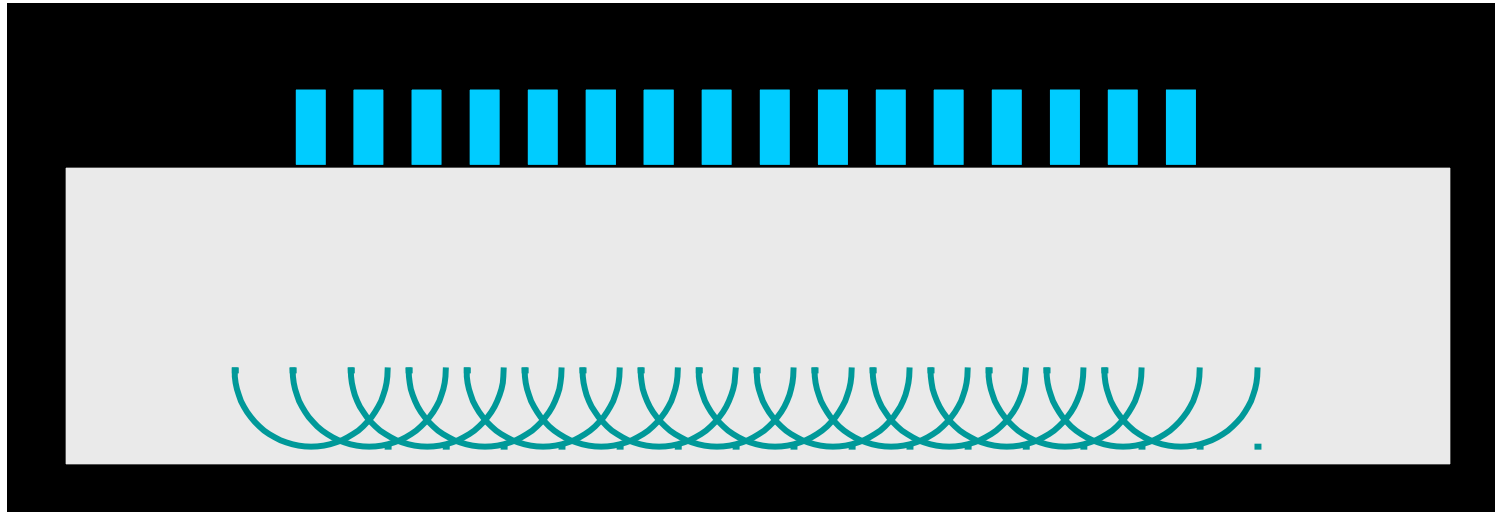
- NDE comprises those test methods used to examine an object without impairing its future usefulness
 - X-Ray, MPI, Dye Penetrant, Visual, etc
 - Ultrasonics and Eddy Current Testing
- Ultrasonic (UT) Phased-Array & Eddy Current (ECT) Array Technologies NOW offers the following advantages
 - Customization for Specific Applications
 - GO-NOGO Inspection
 - Data Recording
 - Light Weight & Portable
 - Speedy and User Friendly



**BASIC UT
PRINCIPLE**

UT Phased Array Technology

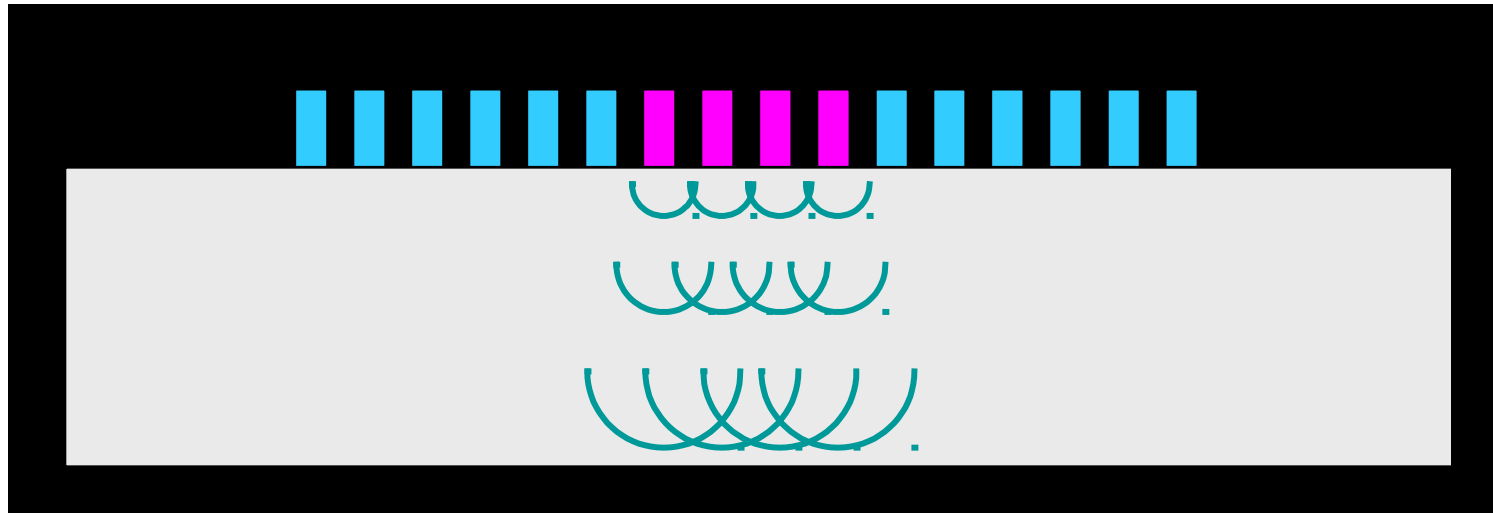
Principles of Operation



- Each element is fired individually, propagating an ultrasonic wave.
- As the wave expands, the wave front expands.
- If all the elements are fired simultaneously, the resulting wave front forms a *longitudinal* or *compression wave*.

Phased Array Technology

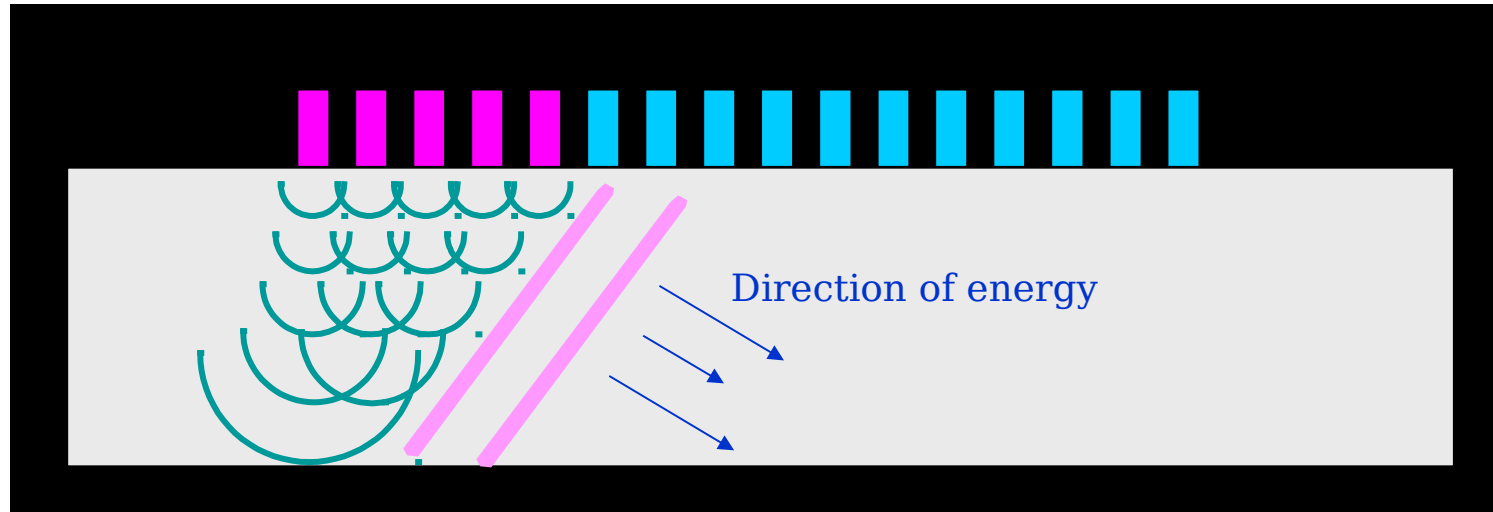
Electronic Scanning



- A group of elements are fired electronically in sequence along the length of the transducer.
- The resulting wave front travels along the length of the phased array transducer.
- No third axis of mechanical movement is required for C-Scan mapping.

Phased Array Technology

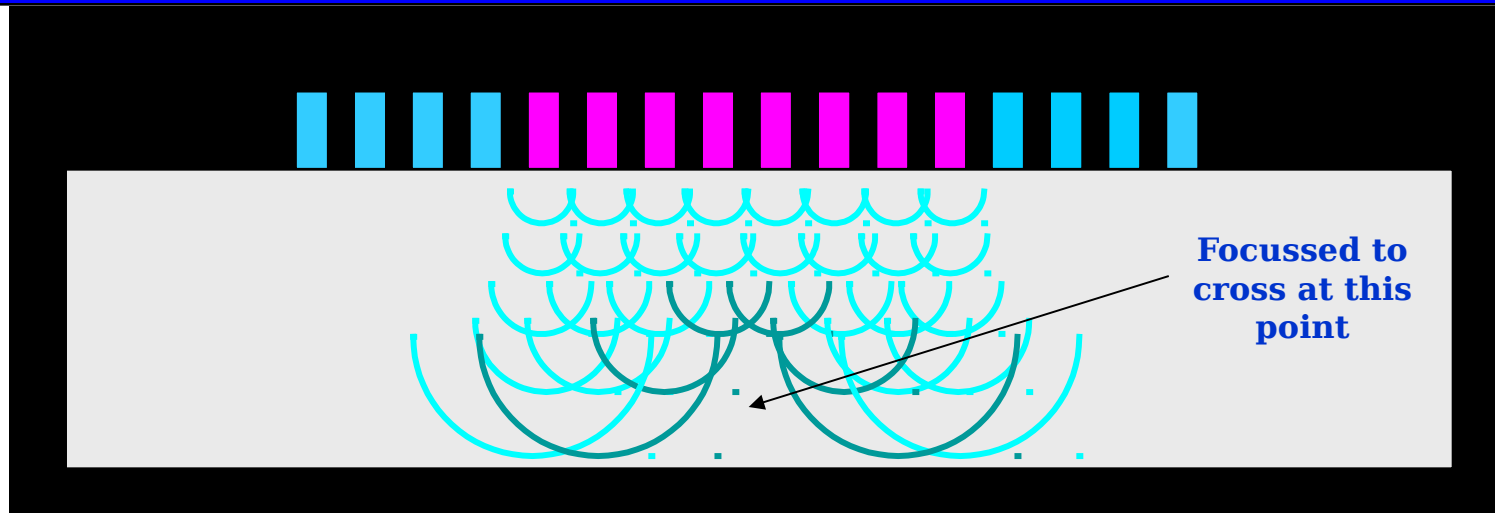
Beam Steering



- *Beam Steering* is accomplished by delaying the pulsing of each element electronically at a set rate.
- The resulting wave front travels along at an angle dependant on the time delay between firings.

Phased Array Technology

Beam Focussing



- *Beam Focussing* is achieved by varying the *time delay* for the pulsing of each element.
- The resulting wave fronts propagate towards one another and focus at a programmed distance from the transducer.
- The actual size of the focal point is determined by the number and size of the elements used

UT PHASED ARRAY ADVANTAGES

- Electronic Scanning thus No Mechanical Movement
 - Fast
 - Simple
 - Reliability
- Enhanced Volume Coverage – Better & Faster Inspection
 - Find smaller defects
 - Size Defects
- Data Imaging Functions
 - Ease Interpretation
 - Real-Time Data Analysis – GO-NOGO Inspection

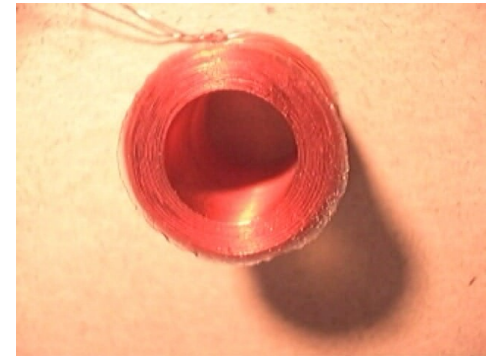
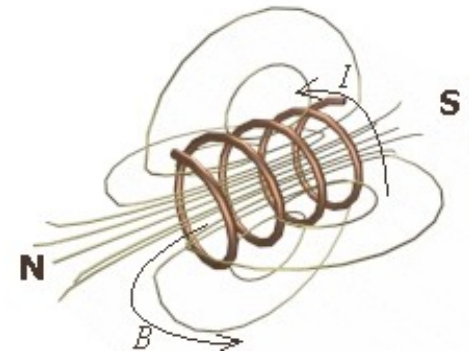
BASIC ECT PRINCIPLES

-ECT is a magnetic technique used for surface inspection

-Based on electromagnetic induction principle

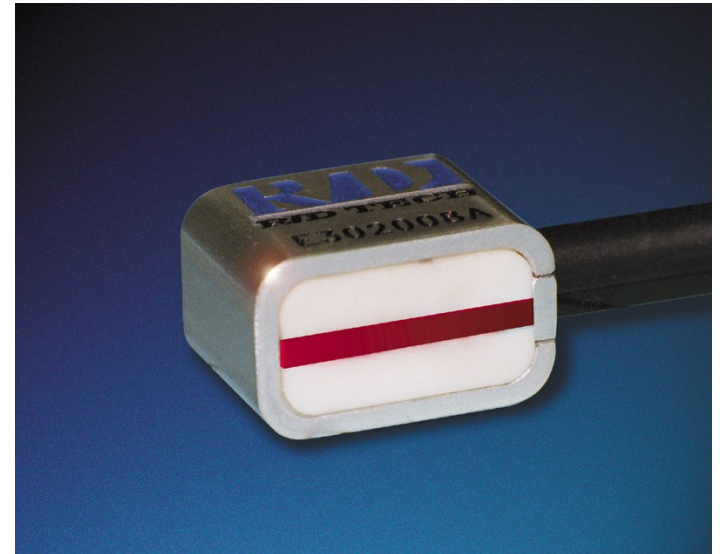
-EC are induced in conducting material when a coil is excited with alternating currents

-Change in coil impedance due to EC distortion at defect locations is measured

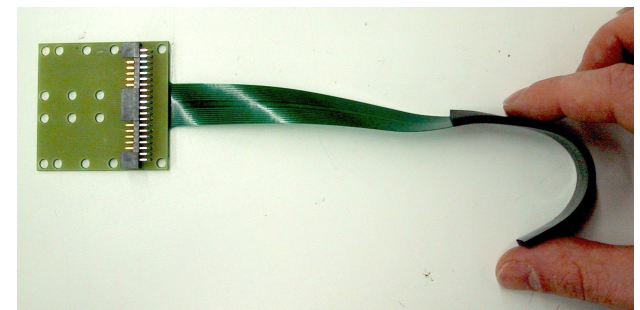
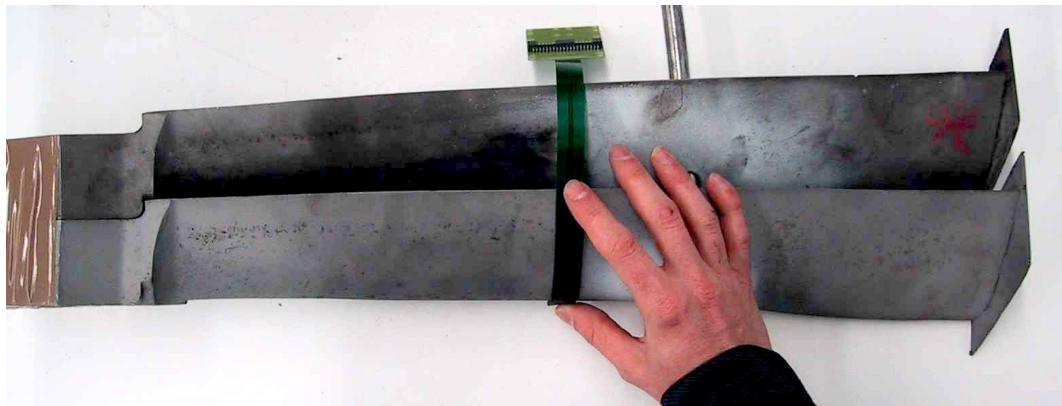
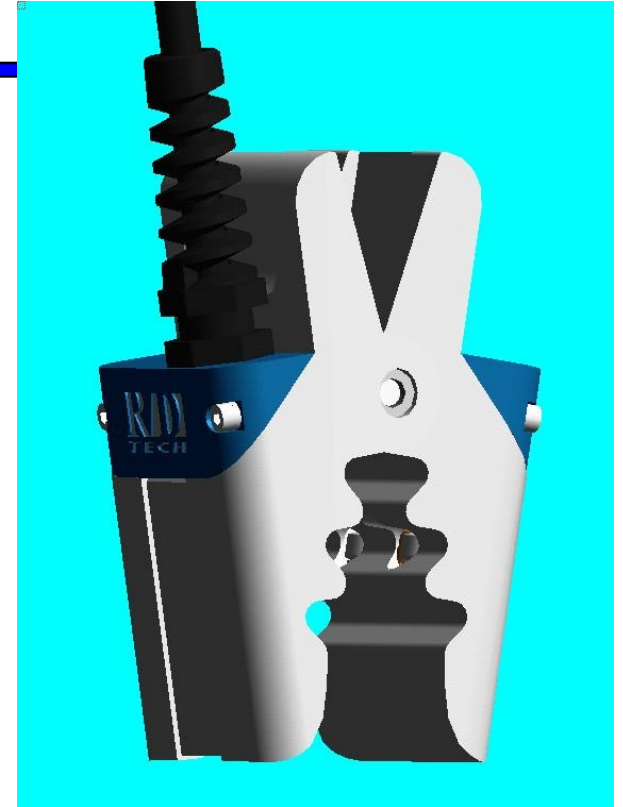
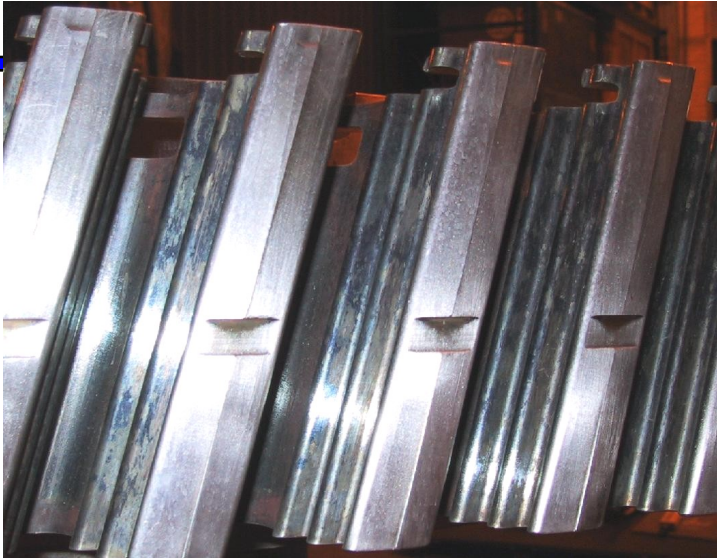


EC ARRAYS

- EC array probe are composed of many coils
- Each coil scans a specific area
- Optimized for a specific application
- No crosstalk between coils
- Any shape is possible



Complex Geometry Inspection using ECT Arrays



ARRAY EC ADVANTAGES

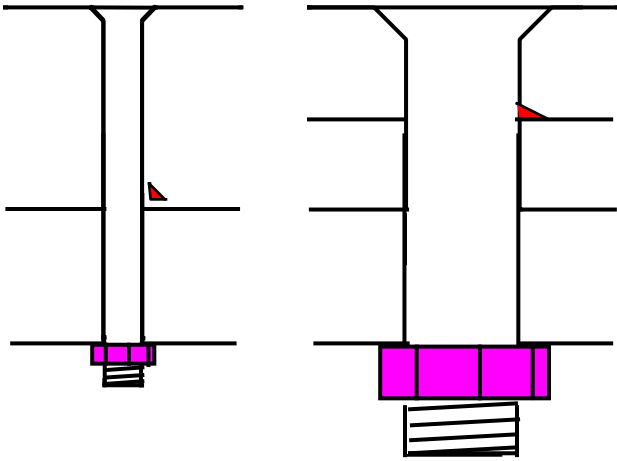
- **ET array simplifies the manipulation because the profile of the probe fits the part to inspect**
- **EC array reduces the inspection time**
- **EC array increases reliability**
- **EC array allow mapping & recording for part wear monitoring purposes**
- **GO-NOGO Inspection**

QUALITY ISSUES RESOLVED WITH NDE ARRAY TECHNOLOGIES

3 CASES

- Aircraft Fuselage Fasteners with UT Phased-Array
- M1 Abrams Road Arm Spindle with UT Phased-Array
- 120mm Mortar Tail Fin Assemblies with UT Phased-Array & EC Array

Fasteners Requirements



- First layer corner cracks
- Fastener hole dia - 3/16" to 5/16"
- Skin thickness 0.100" to 0.300"
- Detection of 0.050" cracks with a 90/95 POD
- System characteristics
 - Fast (less than 1 min per fastener)
 - Handheld, Lightweight & Portable
 - Validated by POD

Primary Application

Faying Surface

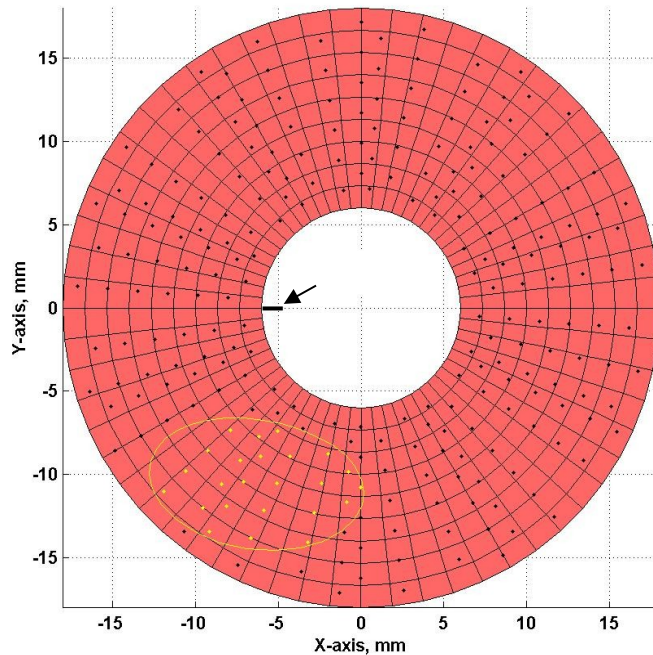
Corner Cracks with
fasteners on aircraft

PHASED ARRAY FASTFOCUS SYSTEM

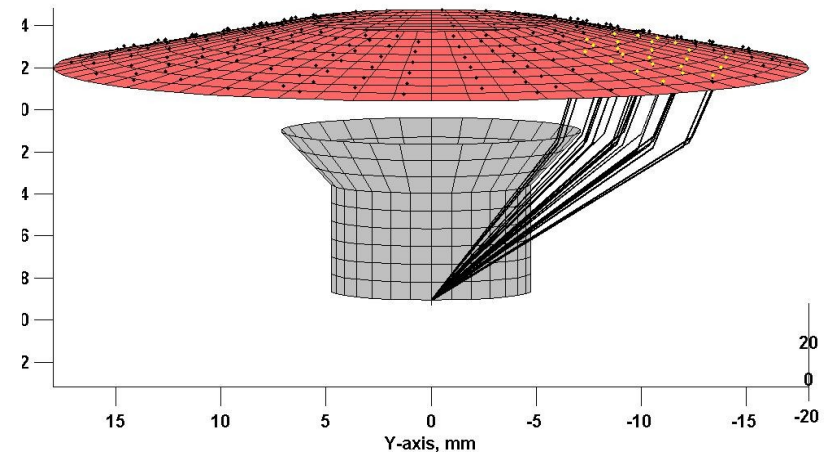
A Three-dimensional Phased Array

Probe

Top View



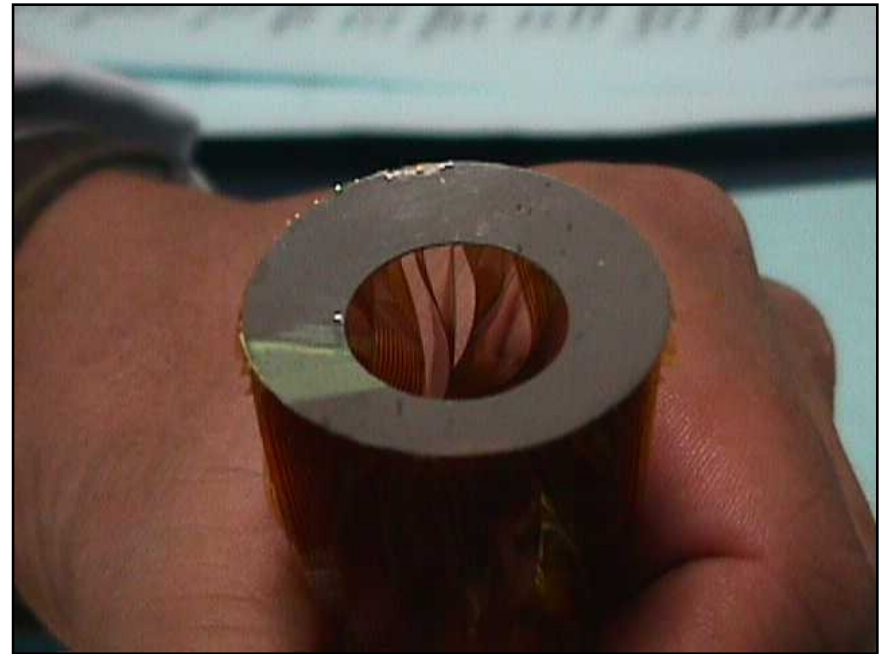
Side View



- Scan around fastener achieved by multiplexing the probe's 504 elements

PHASED ARRAY FASTFOCUS SYSTEM

- A Unique Conical Shaped Phased Array Ultrasonics Probe Has Been Created
- 64/512 PA unit and PC

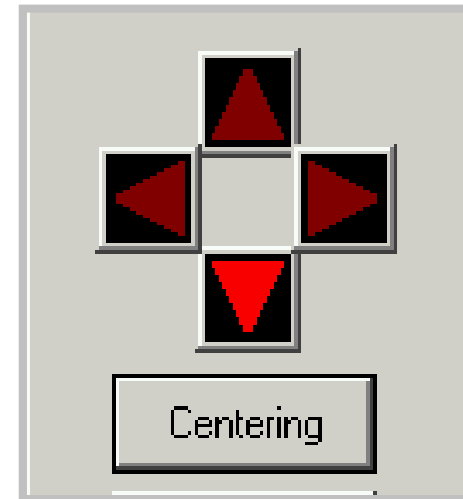
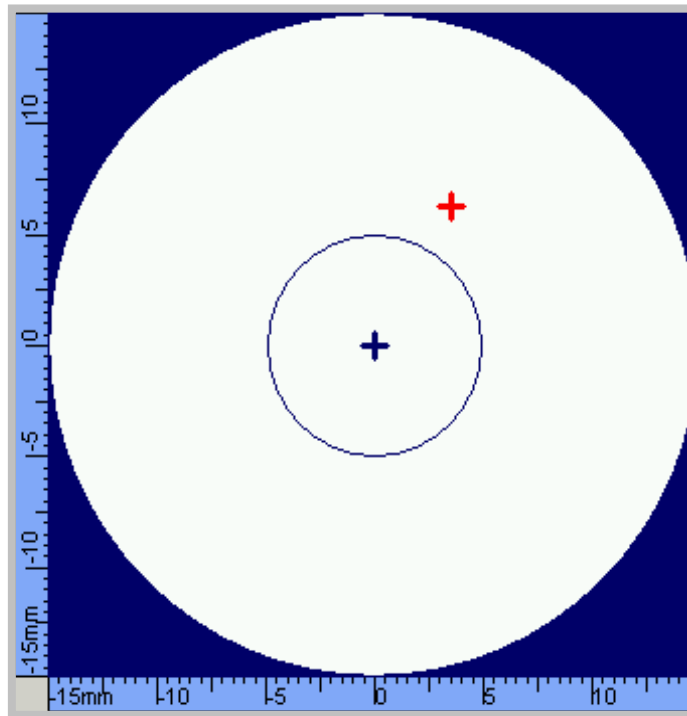


PHASED ARRAY FASTFOCUS SYSTEM

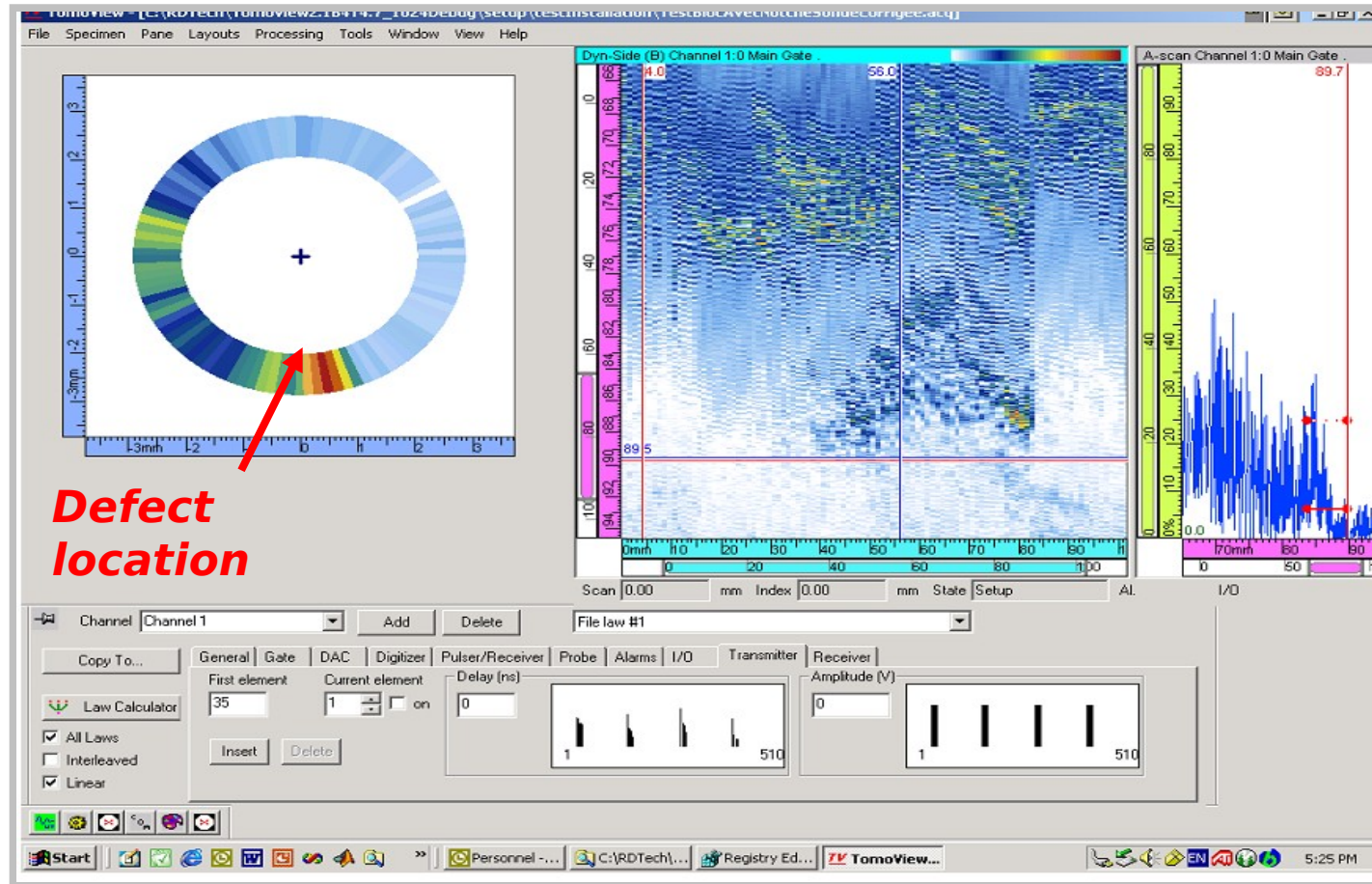


- Housing for:
 - Phased Array Probe
 - Water Coupling
 - Electronics Module

PROBE CENTERING HELP SCREENS



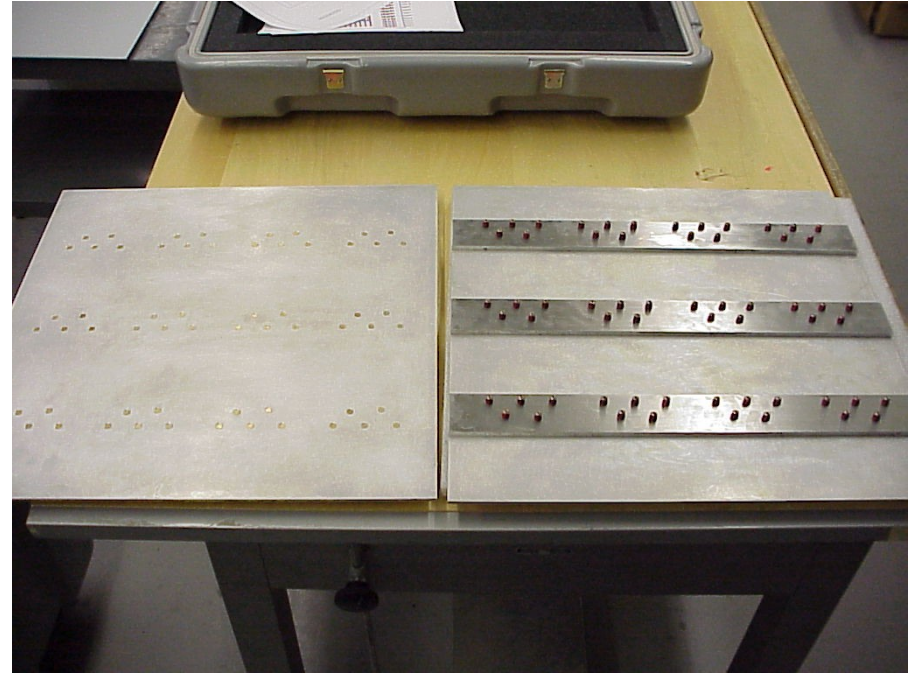
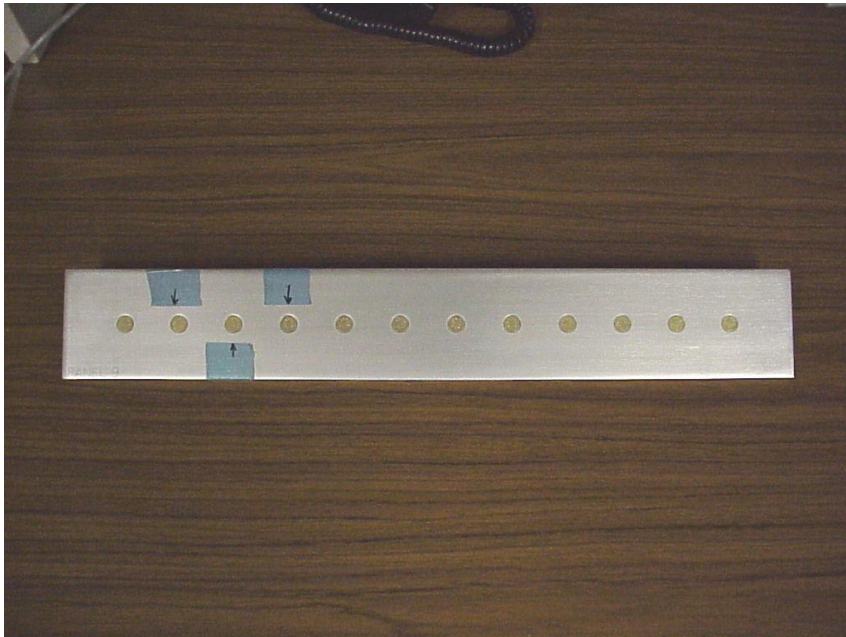
INSPECTION SCREEN EXAMPLE



Each sector is represented by a color level indicating the amplitude of the echo inside a

FOR SYSTEM VALIDATION

Test panels with
fatigue cracks



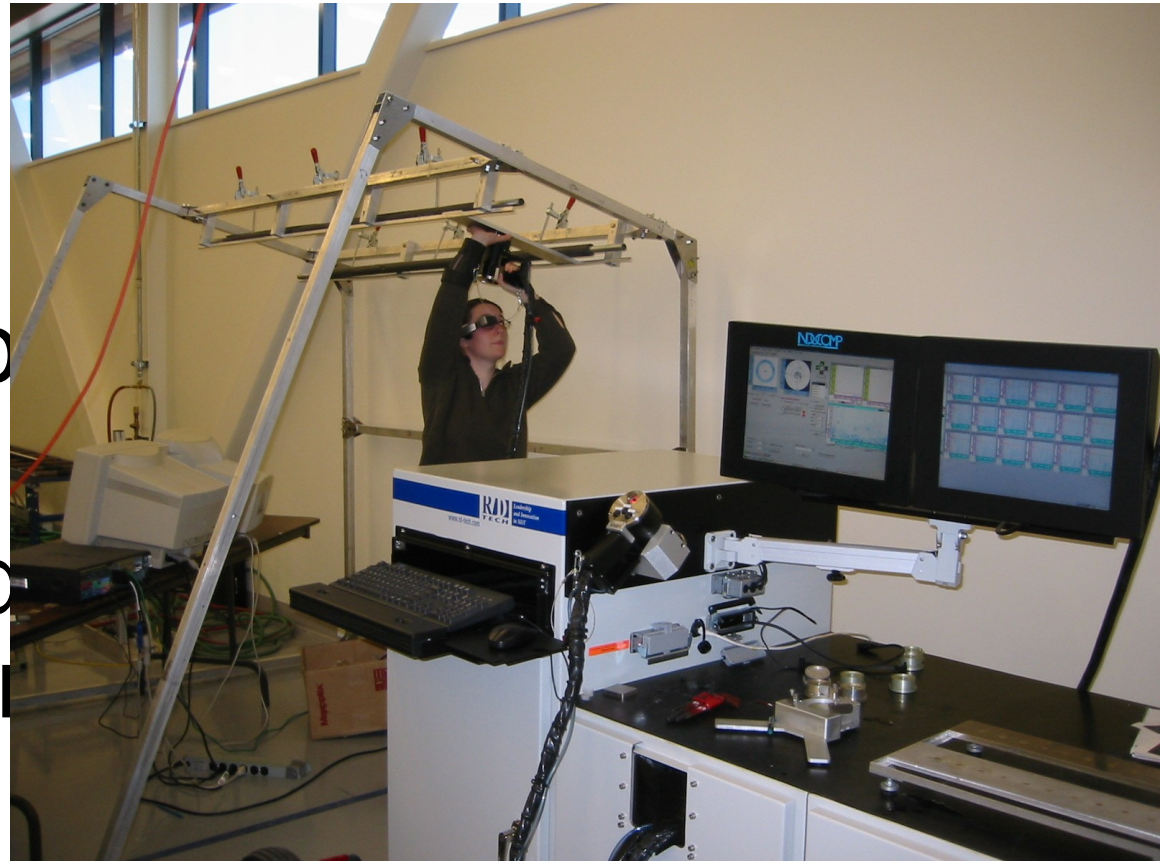
Test panels with
EDM notches

PHASED ARRAY FASTFOCUS SYSTEM

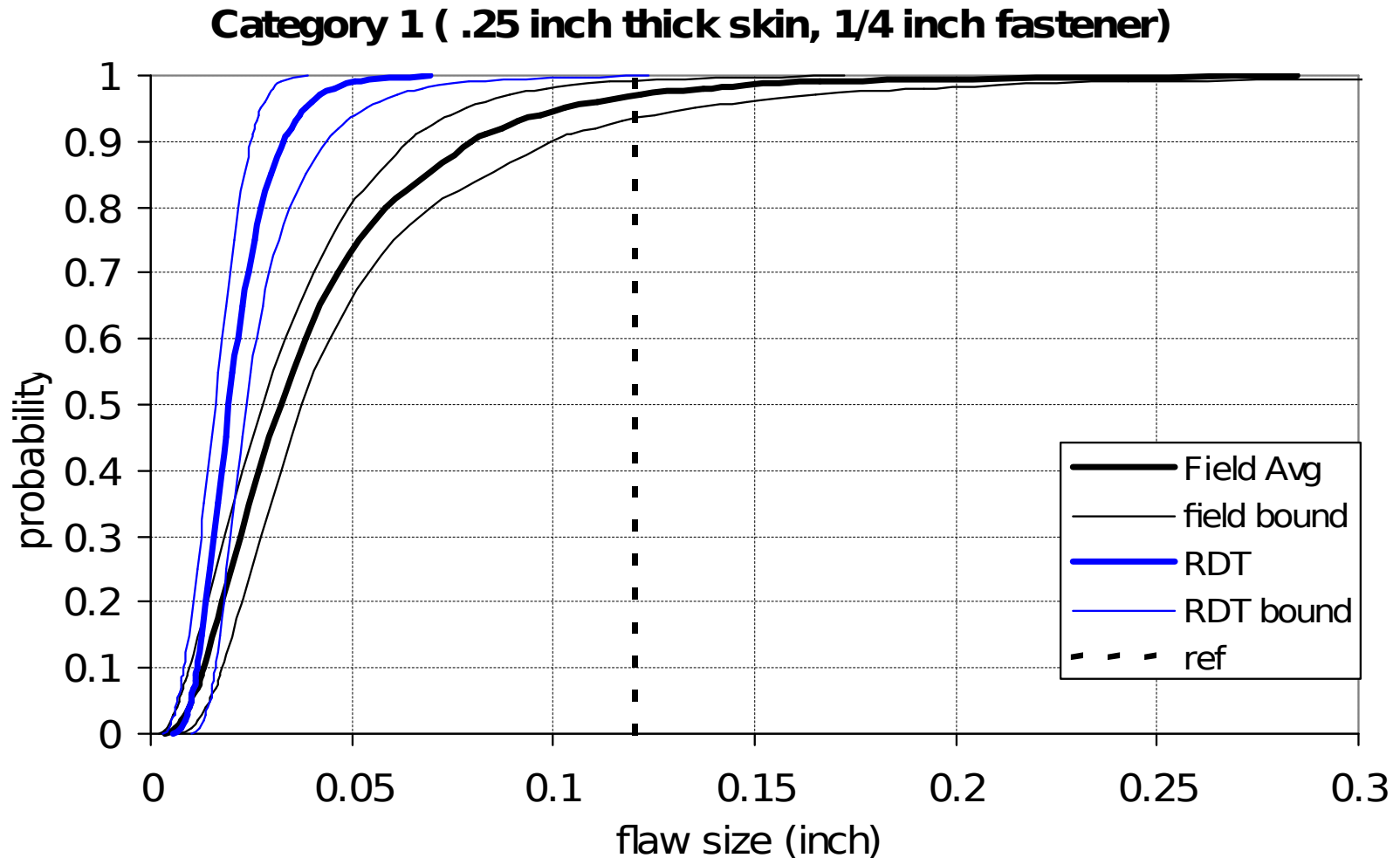


PHASED ARRAY FASTFOCUS SYSTEM

- Heads Up Display
- Overhead Inspection



PROBABILITY OF DETECTION CURVE



Abrams Road Arm Spindle

Mobility = Survivability



4150H Steel Spindle

- The spindles are pressed fit into the road arm and a spacer is pressed fit onto the spindle.
- The failures are occurring at the interface between the road arm and the spacer.
- The failure mechanism appears to be low load, high-cycle fatigue and occurs approximately at the same location for all components.

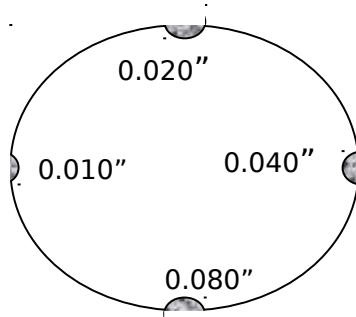
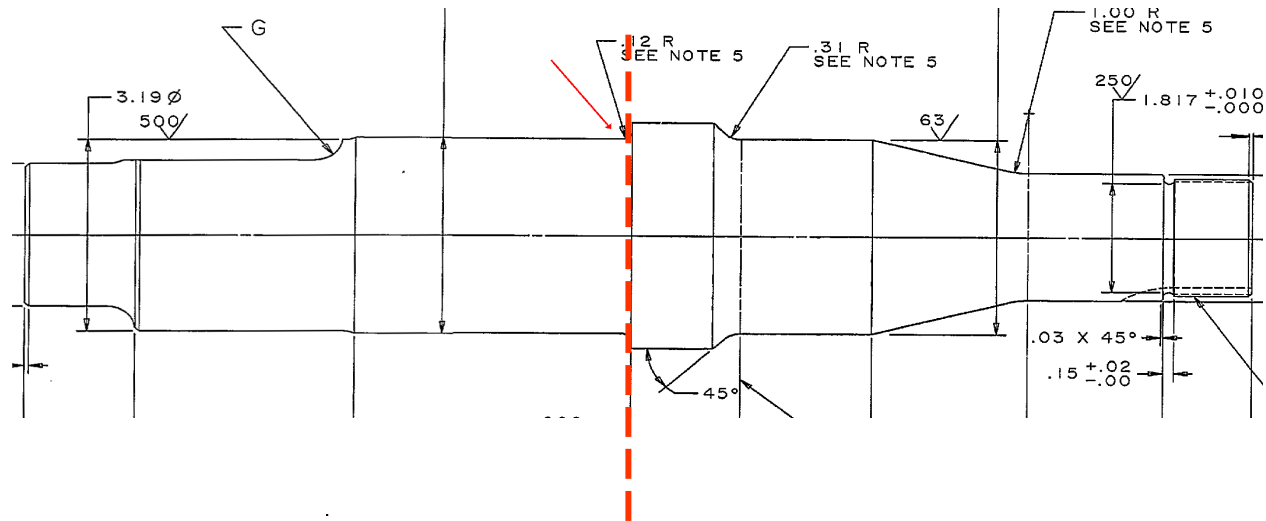


OBJECTIVES

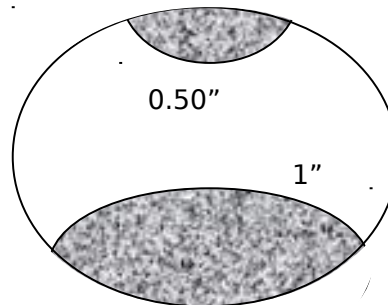
- Detect the Defects
- Size the Defects
- Conduct inspection on Vehicle in Combat Ready State
- GO / NOGO Inspection
 - >Red = Replace
 - >Green = OK
 - >Yellow = Replace in X miles



Detection Limits



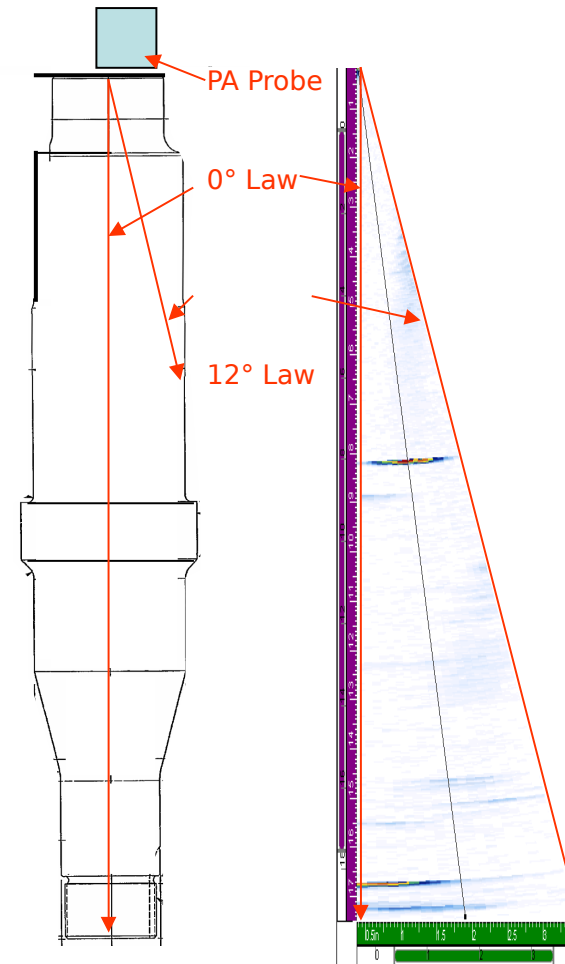
Spindle #1



Spindle #2

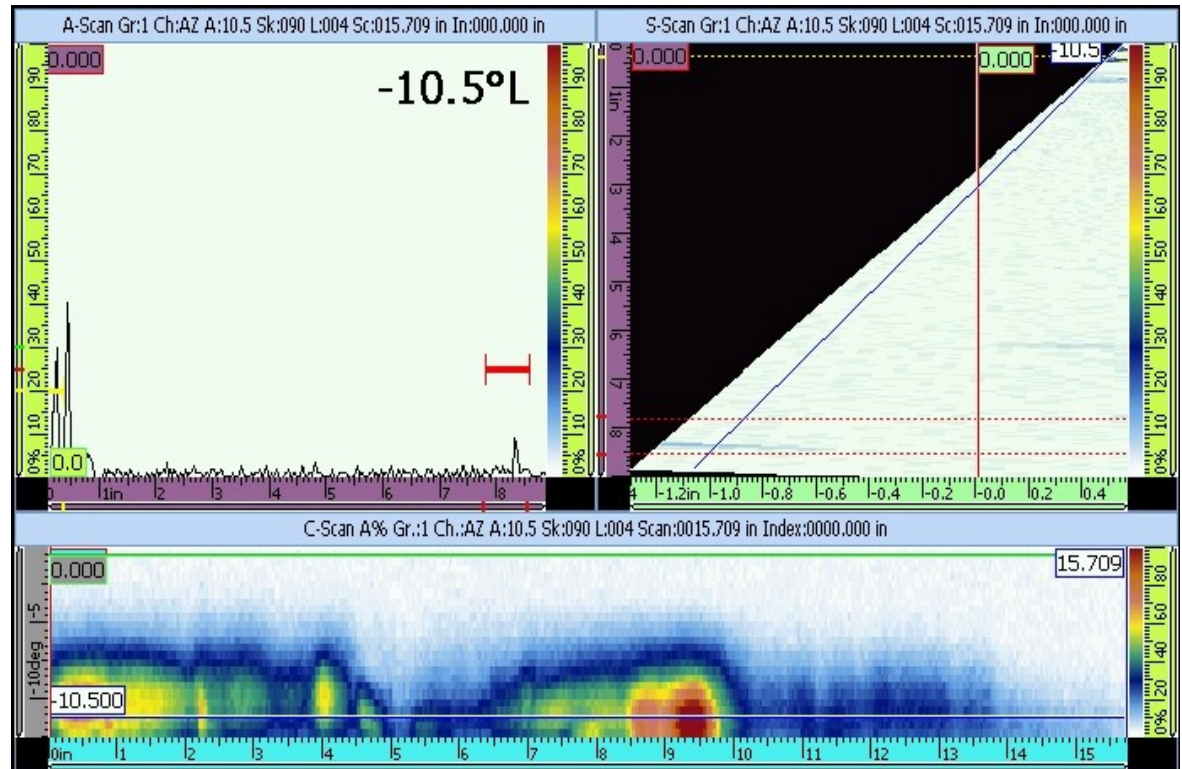
UT Phased Array Solution

- **32-element, 7.5 MHz PA Probe**
- **Contact Inspection**
- **0 to 12 degree Sectorial Scan**



UT Phased Array Results

- 0.020 inch Detection Limit
- Defect Length within 2%
- No Impact from Protective Paint
- In-situ Inspection Feasible



Abrams Road Arm Spindle

Next Steps for Field Ready Solution

- Optimize Probe Design for Sizing Accuracy
- Engineer Mechanical Rotating Device or
- Design 2D Array Probe for Movement Free Electronic Scan
- Software for GO – NOGO Results



Max Duration of Remaining Work = 8 Weeks

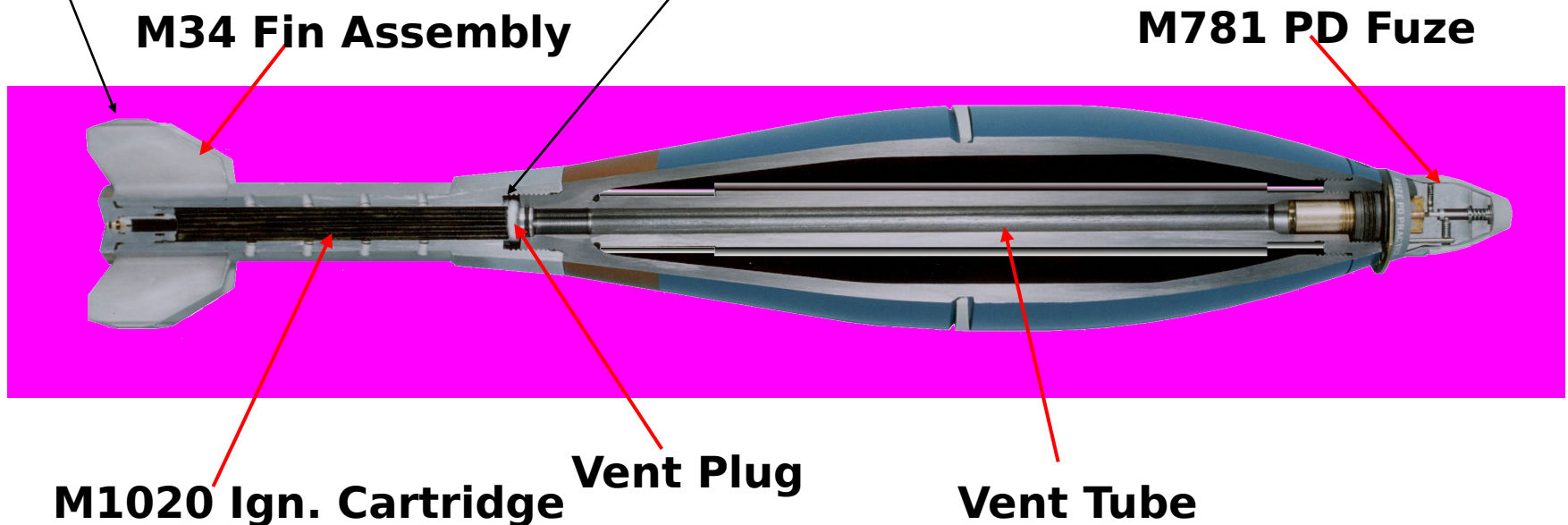
120mm Mortar Tail Fin Assemblies

Problem #1

Cracked Fins

Problem #2

Double Threads



Eddy Current Inspection of Fins

Problem #1- Cracked Fins

200- Channel Array EC System

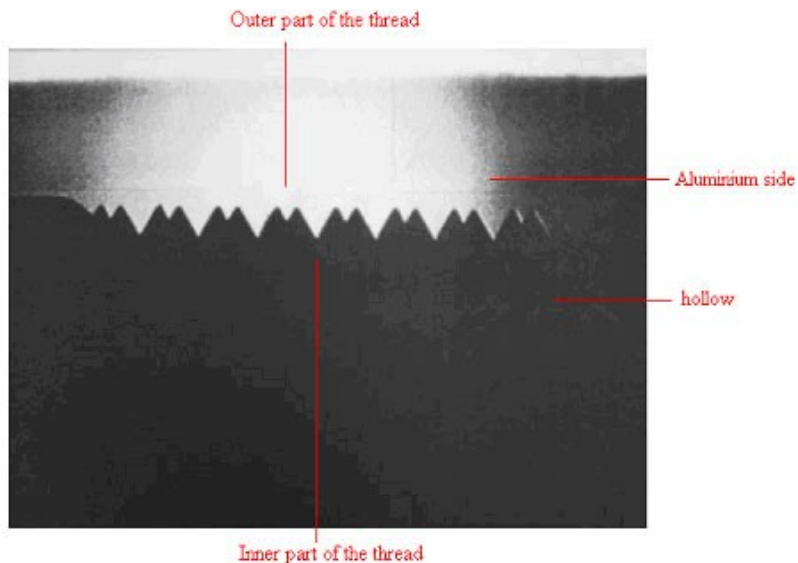


- ◆ PC Based Software
- ◆ QuickScan EC Based System – Array EC
- ◆ Inspection of 800 parts per shift
- ◆ Allows inspection that could not otherwise be executed on complex geometries
- ◆ Replaces old methods such as MPI

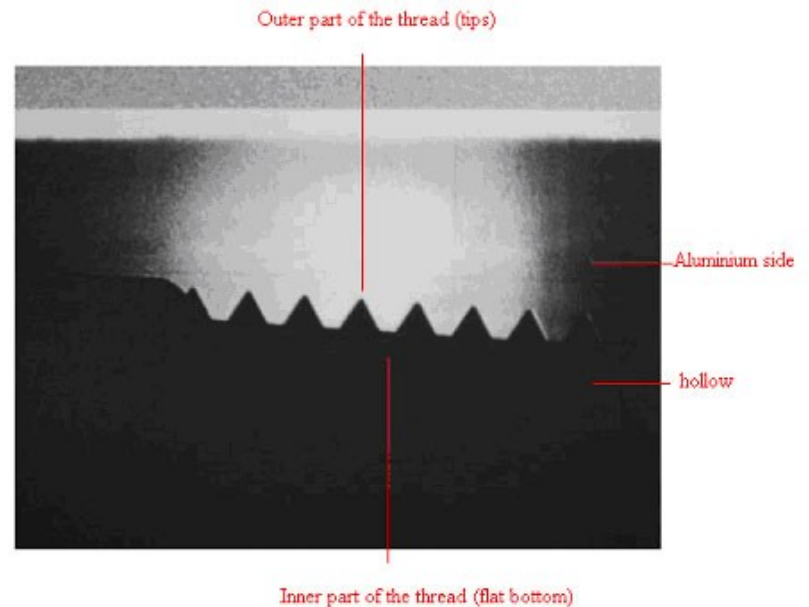
THREAD CONDITIONS

Problem #2 - Double Threads

BAD THREAD

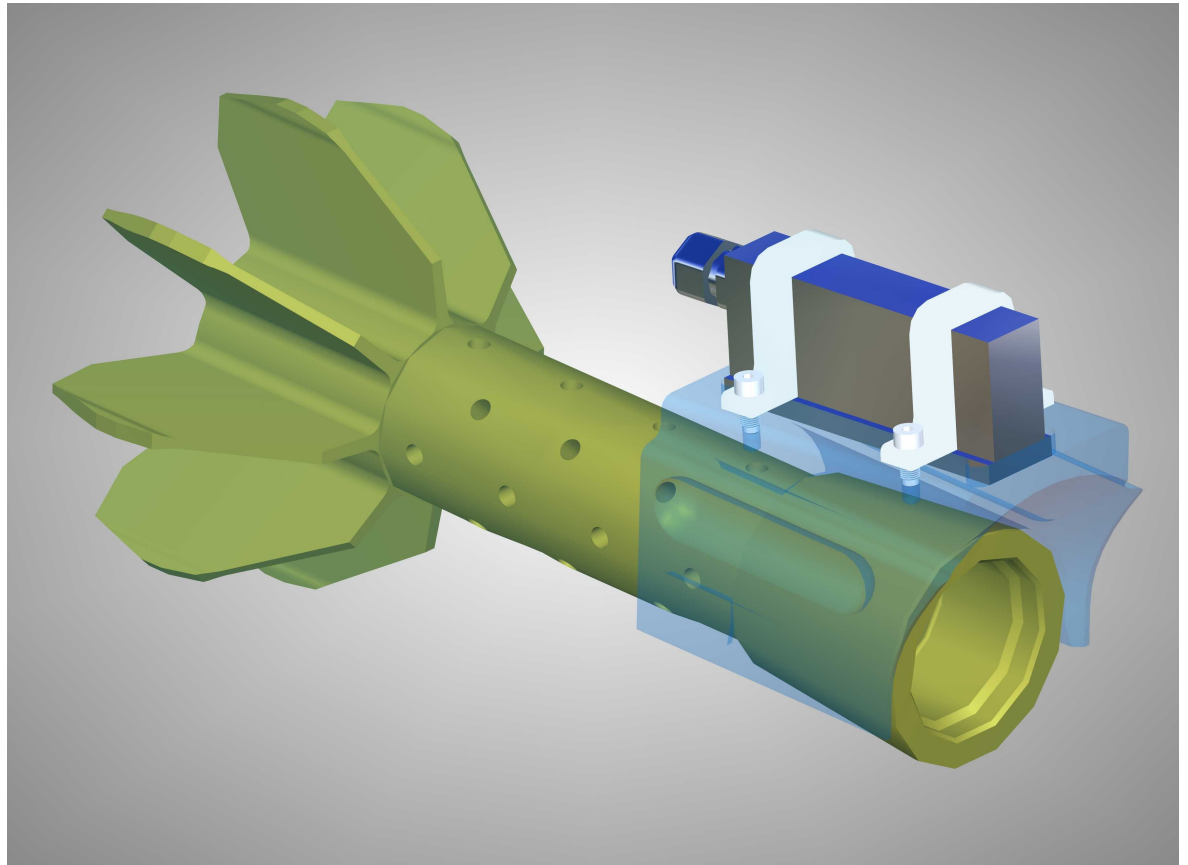


GOOD THREAD

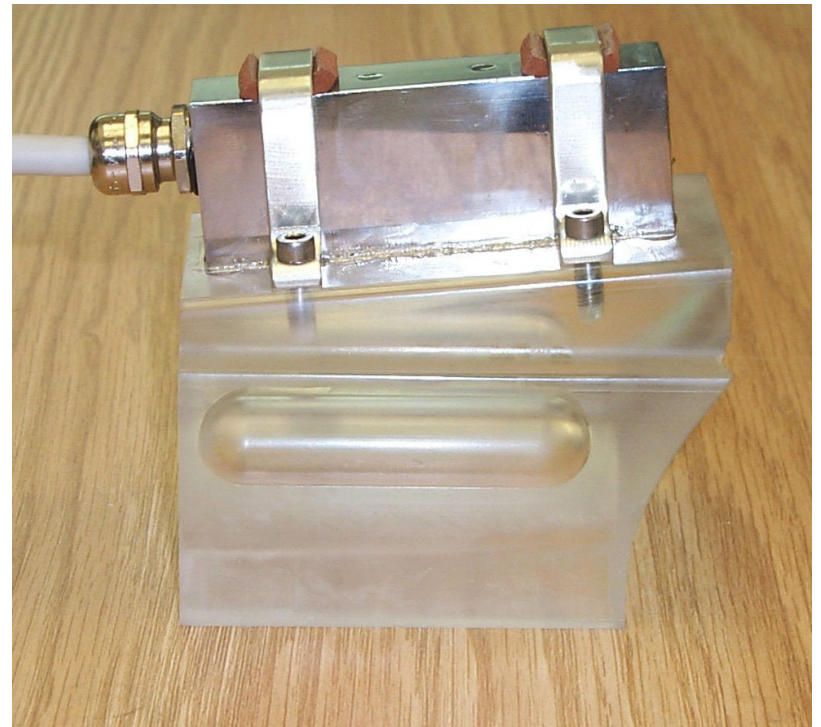
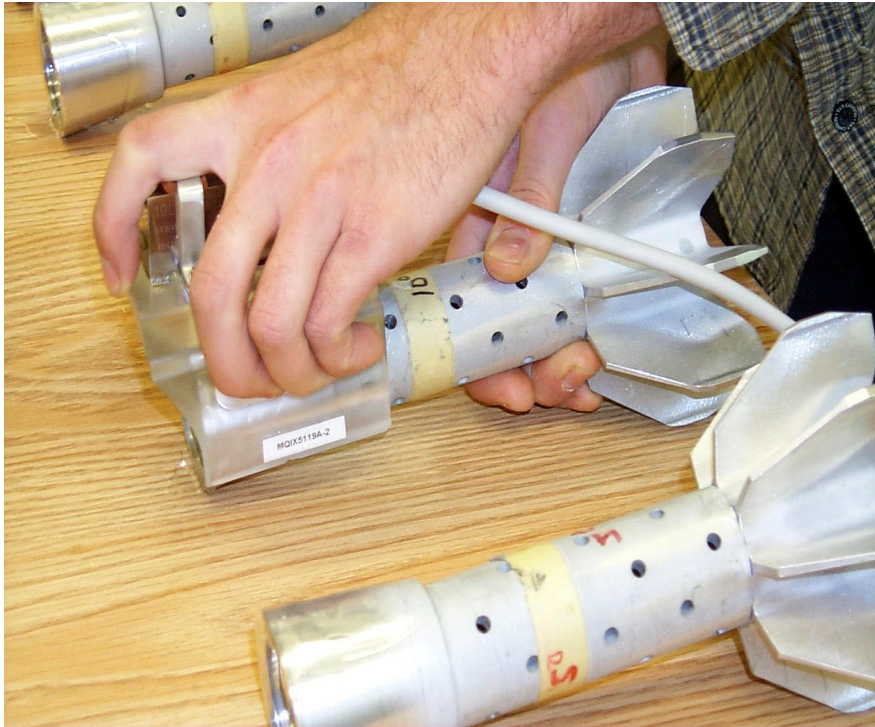


UT PHASED ARRAY SOLUTION

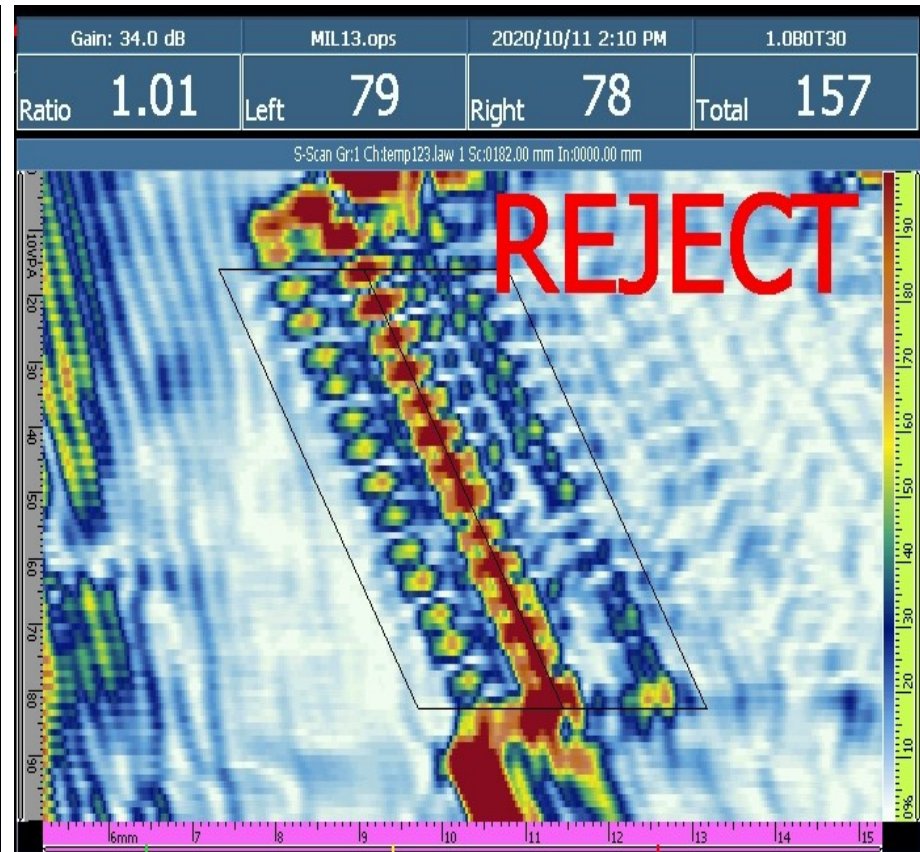
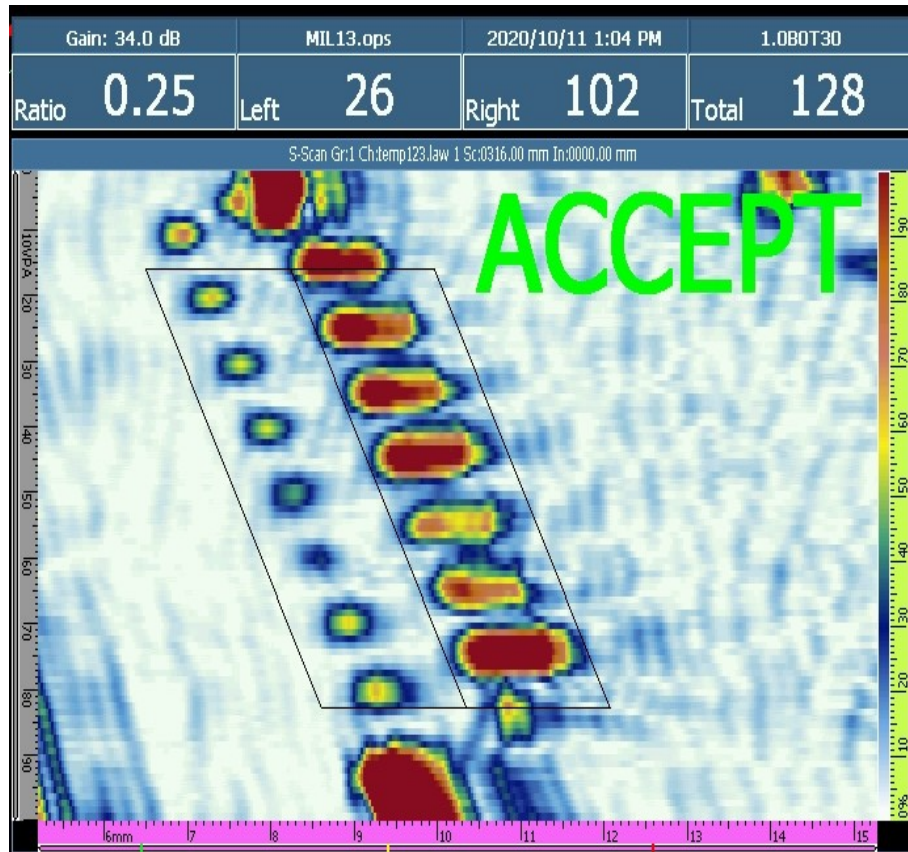
- X RAY does not work
- Conventional UT does not work
- UT Phased Array linear scan works (10 MHz)



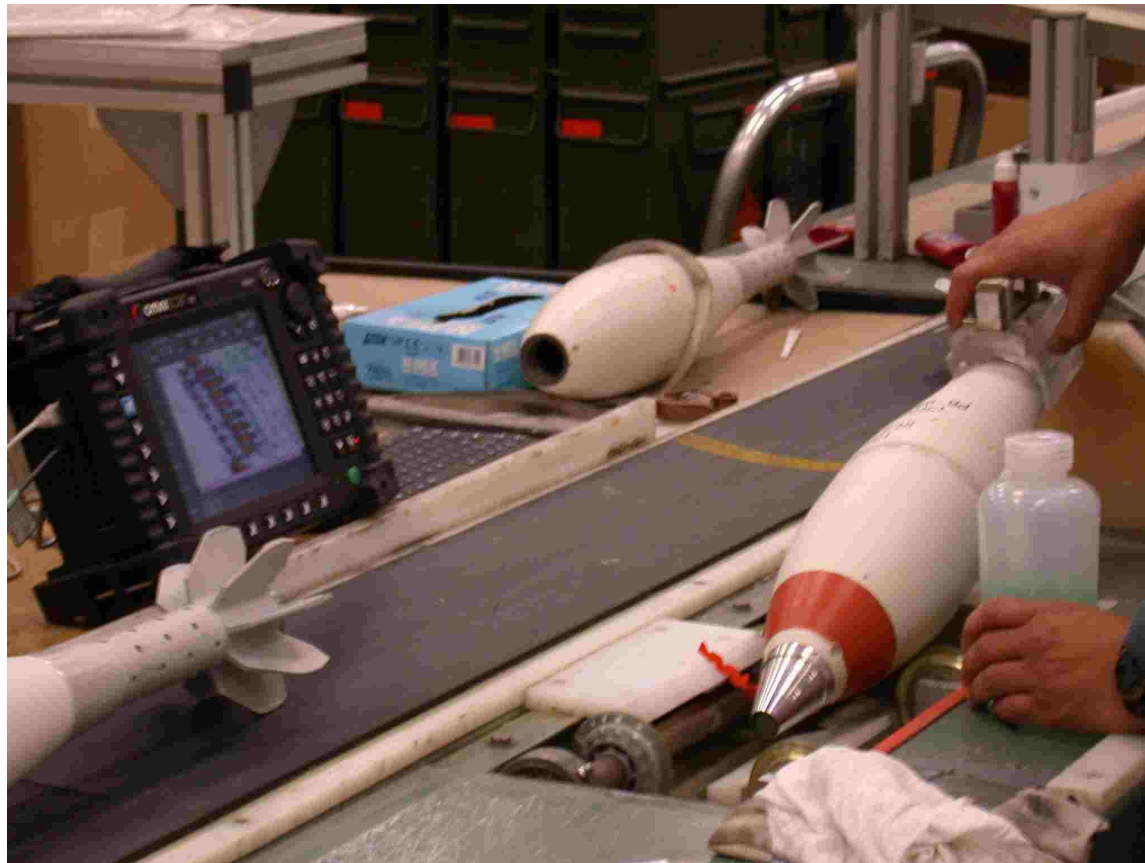
PROBE - WEDGE - SCAN TECHNIQUE



GO - NOGO RESULTS



INSPECTION AT PINEBLUFF ARSENAL OF LIVE AMMUNITION



CONCLUSIONS

NDE for Combat Readiness

- UT Phased Arrays & EC Arrays Systems are valuable tools to monitor the quality of critical components
 - » Customization for Specific Applications
 - » GO-NOGO Inspection
 - » Light Weight & Portable
 - » Fast and User Friendly
- Quality Control Capability at all levels
 - » Manufacturing Floor
 - » T&E & Live Fire Testing
 - » Maintenance at Depots and Field Units

